PATENT SPECIFICATION

843,328

Date of Application and filing Complete Specification: August 1, 1958 *No. 24880 58*

Application made in United States of America on August 26, 1957

Complete Specification Published: August 4, 1960

Index at Acceptance:—**Class 69(2)**, G(5A:5X:6A1B:6A1D:7:9B:13A:14:15).

ERRATUM

SPECIFICATION NO. 843,328

Page 3, line 79, *for* "the rear of the" *read* "carry the ram"

THE PATENT OFFICE,
29th March 1963

pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement :—

This invention is concerned with devices for controlling the motion of hydraulic rams and is more particularly concerned with a device for controlling the motion of a ram so that it moves over the first and greater part of its forward travel at a relatively high rate and over the final part at a slower rate. Such devices are, for example, particularly useful in moulding machines of the kind used for moulding articles from plastic materials.

According to the invention in such a control device the ram has within itself a booster cylinder to which hydraulic fluid under pressure is admitted to move the ram forward at the higher rate while fluid not under pressure is admitted to the rear of the ram. When the ram has moved to a predetermined position which terminates the first stage it initiates the actuation of a valve which cuts off the supply of fluid not under pressure and to admit the fluid under pressure both to the booster cylinder and to the rear of the ram, thereby causing it to advance at the slower rate.

In general, the cross-sectional area of the booster cylinder will be smaller than the cross-sectional area of the space behind the ram.

So that the invention will be better understood, an example of it as applied to a moulding machine will now be described with reference to the accompanying drawings in which :—

Figure 1 is a sectional view through a main ram of the moulding machine;

Figure 2 is a similar sectional view showing the ram partially advanced and our combined prefill and change-over valve in another position (for slow main ram advance);

Fig. 3 is a sectional view on the line 3-3 of Fig. 2 showing details of our valve;

Fig. 4 is a diagrammatic view of our moulding machine showing the main and pilot hydraulic circuits the control valves therein and three limit switches controlled by the main ram; and

Fig. 5 is an electrical diagram showing the electric control circuit for the hydraulic circuits and including the three limit switches of Fig. 4.

In the accompanying drawings the reference numeral 10 indicates a hydraulic cylinder and 12 a main ram reciprocable therein. A speed booster ram 14 enters a booster ram cavity 15 within the main ram 12 and is provided with a stem 16 having a threaded portion 18. A booster ram lock nut 20 is screwed thereon for retaining the booster ram 14 in fixed relation to the cylinder 10.

A combined prefill and change-over valve disc 26 is adapted to be normally seated against a seat 28 by a valve closing spring 30. The valve disc 26 has a tubular stem 24 which terminates in a valve actuating piston 22. The tubular stem 24 and the disc 26 surround the booster ram 14 to constitute what is generally termed a " wrap-around " valve. The piston 22 is reciprocable in a cavity 23 of the hydraulic cylinder 10 which is ported at 40 to allow the flow of pilot oil to and from the cavity behind the piston 22 as will hereinafter appear. The tubular stem 24 is

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International Classification:—B30b.

COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in and relating to Control Devices for Hydraulic Rams

We, National Automatic Tool Company, Inc., a Corporation of the State of Indiana, United States of America, of Richmond, Indiana, United States of America, do hereby declare the invenion, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement :—

This invention is concerned with devices for controlling the motion of hydraulic rams and is more particularly concerned with a device for controlling the motion of a ram so that it moves over the first and greater part of its forward travel at a relatively high rate and over the final part at a slower rate. Such devices are, for example, particularly useful in moulding machines of the kind used for moulding articles from plastic materials.

According to the invention in such a control device the ram has within itself a booster cylinder to which hydraulic fluid under pressure is admitted to move the ram forward at the higher rate while fluid not under pressure is admitted to the rear of the ram. When the ram has moved to a predetermined position which terminates the first stage it initiates the actuation of a valve which cuts off the supply of fluid not under pressure and to admit the fluid under pressure both to the booster cylinder and to the rear of the ram, thereby causing it to advance at the slower rate.

In general, the cross-sectional area of the booster cylinder will be smaller than the cross-sectional area of the space behind the ram.

So that the invention will be better understood, an example of it as applied to a moulding machine will now be described with reference to the accompanying drawings in which :—

Figure 1 is a sectional view through a moulding machine embodying our present invention and showing the main ram thereof in the retracted position at the start of a cycle and our combined prefill and change-over valve in a position for rapid advance of the main ram of the moulding machine;

Figure 2 is a similar sectional view showing the ram partially advanced and our combined prefill and change-over valve in another position (for slow main ram advance);

Fig. 3 is a sectional view on the line 3-3 of Fig. 2 showing details of our valve;

Fig. 4 is a diagrammatic view of our moulding machine showing the main and pilot hydraulic circuits the control valves therein and three limit switches controlled by the main ram; and

Fig. 5 is an electrical diagram showing the electric control circuit for the hydraulic circuits and including the three limit switches of Fig. 4.

In the accompanying drawings the reference numeral 10 indicates a hydraulic cylinder and 12 a main ram reciprocable therein. A speed booster ram 14 enters a booster ram cavity 15 within the main ram 12 and is provided with a stem 16 having a threaded portion 18. A booster ram lock nut 20 is screwed thereon for retaining the booster ram 14 in fixed relation to the cylinder 10.

A combined prefill and change-over valve disc 26 is adapted to be normally seated against a seat 28 by a valve closing spring 30. The valve disc 26 has a tubular stem 24 which terminates in a valve actuating piston 22. The tubular stem 24 and the disc 26 surround the booster ram 14 to constitute what is generally termed a " wrap-around " valve. The piston 22 is reciprocable in a cavity 23 of the hydraulic cylinder 10 which is ported at 40 to allow the flow of pilot oil to and from the cavity behind the piston 22 as will hereinafter appear. The tubular stem 24 is

provided with guide fins 25 (Fig. 3) slidable in an enlargement 27 of the cavity 23.

The booster ram stem 16 is provided with several so-called slow advance ports 32 that are normally not covered by the tubular stem 24 as shown in Fig. 2 because the spring 30 urges the stem 24 away from them. When oil under pressure is introduced through the port 40 the stem 24 covers the ports 32 (Figs. 1 and 4).

Within the hydraulic cylinder 10 there is an annular pull back area 34 and a pull back port 36 communicates therewith. The booster ram 14 at its left-hand end is provided with a ram port 38. The ports 36 and 38 are adapted for connection to a main system hydraulic circuit which will now be described.

Referring to Fig. 4 a main system hydraulic pump 42 is provided which may be of the constant delivery type receiving oil from a reservoir 46 through an oil supply line 48. An out flow line 62 extends from the pump 42 to a main circuit directional control valve 56 and to a relief valve 52. The relief valve 52 limits the pressure in the line 62 and permits the excess oil to flow through a return line 50 back to the reservoir 46.

A pilot system hydraulic pump 44 is provided also of the constant delivery type, but of less capacity than the pump 42, and an out flow line 64 extends therefrom to a pilot circuit directional control valve 58. A relief valve 54 limits the pressure in the line 64 and is connected on its outlet side to the oil return line 50.

The main circuit directional control valve 56 is connected by hydraulic lines 66 and 68 to the ram port 38 and the pull back port 36 respectively. The pilot circuit directional control valve 58 is connected by a hydraulic line 70 to the port 40. The valve 56 is shown in the neutral " N " position in Fig. 4 under the action of a pair of centering springs 74 and has forward and return positions indicated " FRD " and " RET " respectively. It may be shifted to the forward position by energisation of a solenoid S-1 and to the return position by energisation of a solenoid S-3 both of which are indicated " OFF."

The neutral section of the valve 56 is provided with suitable passageways which relieve all pressure in the hydraulic lines 66 and 68 and which bypass the oil constantly pumped by the pump 42 from the out flow line 62 to the return line 50. The forward section of the valve 56 has passageways 76 and 78 for permitting flow from 62 to 66 and from 68 to 50 respectively. The return section of the valve 56 has passageways 80 and 82 permitting connection between 66 and 50, and between 62 and 68 respectively.

The valve 58 has " ON " and " OFF " sections in which are passageways 84 and 86 respectively permitting in the " ON " position flow from 64 to 70 and in the " OFF " position return flow from 70 to 50. The valve 58 is normally in the " OFF " position under the action of a spring 88 and is moved to the " ON " position by a solenoid S-2 which is shown in Fig. 4 in the " ON " or energised position.

A limit switch actuator 72 extends from the main ram 12 and is adapted to actuate three limit switches LS-1, LS-2 and LS-3 which are normally closed, normally closed and normally open respectively as indicated " NC " and " NO " adjacent the limit switches. The limit switch LS-1 has been moved to the " OFF " position by the actuator 72 whereas the limit switches LS-2 and LS-3 are " ON " and " OFF " respectively as also indicated.

Referring to Fig. 5 an electric circuit is shown which is supplied with electricity from current supply wires 90 and 92. The circuit illustrated includes the three limit switches just referred to and the three solenoids S-1, S-2 and S-3 shown in Fig. 4. It further includes control relays CR-1, CR-2 and CR-3 (the circles so designated being the relay coils). The control relay CR-1 controls two sets of normally open contacts CR1-1 and CR1-2. The control relay CR-2 when energised closes normally open contact CR2-1 which in Fig. 5 are shown closed because CR-2 is energised by reason of LS-2 being closed which is the normal position of this limit switch. The control relay CR-3 controls four sets of contacts, as follows :—

CR3-1 which are normally closed,
CR3-2 which are normally open,
CR3-3 which are normally open, and
CR3-4 which are normally open.

Limit switch LS-1 is normally closed but is shown open in Fig. 5 to correspond to the position of the parts in Fig. 4 so that the circuit as illustrated in Fig. 5 is ready for operation when desired. To start the operation a cycle start switch 60 is provided. This is a push button type of switch and is normally open as illustrated.

Closing the cycle start button 60 energises S-1 and CR-1. The energisation of S-1 moves the control valve 56 to the forward position so that oil from the pump 42 flows through 62, 76 and 66 to the ram port 38 and then through a bore 19 of the ram into the booster ram cavity 15. This drives the main ram 12 forward rapidly because of the small area of the booster ram 14. Gravity flow of oil from the reservoir 46 through the open valve 26-28 makes up the volume of oil required in the cylinder 10 back of the main ram 12 for free advance of the ram 12. The oil displaced by the pull back area 34 flows from the port 36 through 68, 78 and 50 to the reservoir 46.

During the rapid advance of the ram 12, the pump 44 is supplying pilot oil through

64, 84, 70 and 40 to the cavity 23, thus acting on the valve actuating piston 22 to keep the valve 26-28 open.

The energisation of CR-1 closes switches CR1-1 and CR1-2 to condition the circuits for CR-3 and S-3 for a subsequent operation.

When the actuator 72 reaches the limit switch LS-2 it turns it off for de-energising the control relay CR-2. The opening of its contacts CR2-1 de-energises the solenoid S-2 thereby shifting the valve 58 from the "ON" position to the "OFF" position and permitting out flow of oil from the cavity 23 under the action of the spring 30 through 40, 70, 86 and 50 to the reservoir 46. The valve 26-28 thereupon closes as in Fig. 2 and this opens the change-over portion of the valve by reason of the tubular stem 24 uncovering the slow advance ports 32. Thereupon the oil being supplied through the hydraulic line 66 flows to both the booster ram cavity 15 and the cylinder 10 behind the main ram 12 for acting on both their areas to effect slow advance at a reduced speed in inverse ratio to their areas. This prevents harmful impact between working parts such as injection moulds when they close and permits full area tonnage for clamping the mould parts closed. Advance continues until resistance is met and the pressure builds up to whatever is required for the work.

When the actuator 72 reaches the switch LS-3 it is closed to energise CR-3 which results in de-energisation of the solenoid S-1 by opening of the switch CR3-1. At the same time CR3-2 and CR3-4 are closed to energise S-2 and S-3. When the hydraulic circuit is in this condition the valve 56, in its return position because of S-3 being energised, directs the oil from 62 through 82 to 68 and 36 thus acting on the pull back area 34 of the ram 12 and the valve 26-28 is open because of S-2 being energised so that the oil displaced from behind the ram 12 flows past valve disc 26 and through valve seat 28 back to the reservoir 46 while the oil displaced from the booster ram cavity 15 flows through 19, 38, 66, 80 and 50 back to the reservoir 46. The ram 12 is retracted rapidly because the pull back area 34 is relatively small. CR3-3 is at this time closed to shunt LS-3 and thus keep CR-3 energised after LS-3 reopens and until LS-1 opens to de-energise CR-1. This opens CR1-1 to de-energise CR-3 so it is ready for the next cycle.

When LS-1 is contacted the solenoid S-3 is de-energised by CR-1 opening CR1-2 so that the valve 56 returns to neutral and bypasses oil from 62 to 50 and this reduces the pressure in the main hydraulic system to substantially zero. This is the "rest" condition and thereafter another cycle may be started by depressing the cycle start button 60.

While there is described above a moulding machine of the open circuit type using constant displacement pumps and a 4-way valve, the invention applies equally well to moulding machines of the closed circuit type employing variable reversible pumps such as shown in Patent No. 820644.

WHAT WE CLAIM IS:—

1. A control device for controlling the motion of a hydraulic ram so that it moves forward over the first and greater part of its forward travel at a relatively high rate and over the final stage of its forward travel at a slower rate in which the ram has within itself a booster cylinder to which hydraulic fluid under pressure is admitted to the rear of the forward at the higher rate while fluid not under pressure is admitted to the rear of the ram, there being a tubular booster ram projecting into said booster cylinder through which the hydraulic fluid under pressure flows and in which, when the ram has moved to a predetermined position which terminates the first stage, it initiates the actuation of a valve surrounding said booster ram which cuts off the supply of fluid not under pressure and admits the fluid under pressure both to the booster cylinder and, through a port in said booster ram opened by said valve upon its movement to its cut off position, to the rear of the ram thereby causing it to advance at the slower rate.

2. A device according to claim 1 wherein the cross-sectional area of the booster cylinder is less than that cross-sectional area of the space behind the ram.

3. A device according to claim 1 or claim 2 in which the booster ram is stationary relatively to the ram cylinder and in which the booster ram port is normally closed by the valve but which, when opened, admits the fluid at pressure to the rear of the ram.

4. A device according to any one of claims 1, 2 or 3 wherein the valve has means for normally holding it in a position in which the supply of fluid under pressure to the rear of the ram is opened.

5. A device according to any preceding claim in which the valve is piston operated by the hydraulic fluid.

6. A device according to claim 3 and any claim appendant thereto wherein the valve comprises a sleeve surrounding the booster ram and sliding on it having at one end a piston which slides in a cylinder and at the other a flange which constitutes the seating part of the valve and which seats on a corresponding part integral with the main cylinder.

7. A device according to any preceding claim in which the ram over part of its length is of smaller diameter than the cylinder so as to provide a pull back cavity surrounding the ram into which fluid under pressure can be admitted for carrying the ram rearwardly.

8. A device according to any preceding claim comprising a main fluid pump and an

associated control valve for controlling the output of the pump so as to divert the pump output so as to make the ram move first forwardly and then backwardly, a pilot pump providing fluid for operating the valve and an associated control valve and an electric circuit for actuating the control valves having a start switch and three limit switches, the limit switches being actuated by the ram in sequence to change to slow forward speed, to initiate the rearward travel and to stop the rearward travel.

9. A moulding machine having a control device as claimed in any preceding claim.

10. A control device substantially as described herein with reference to Figs. 1-5 of the accompanying drawings.

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Fig. 1

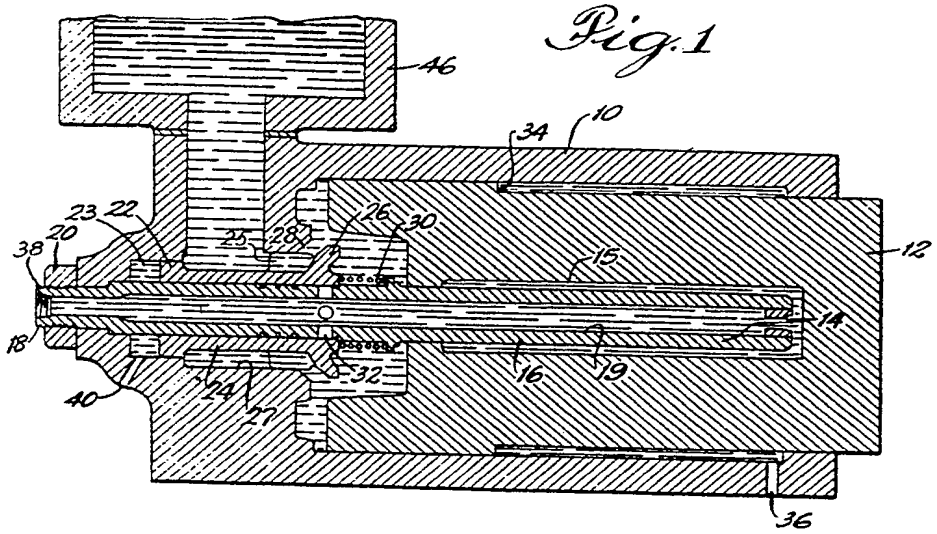
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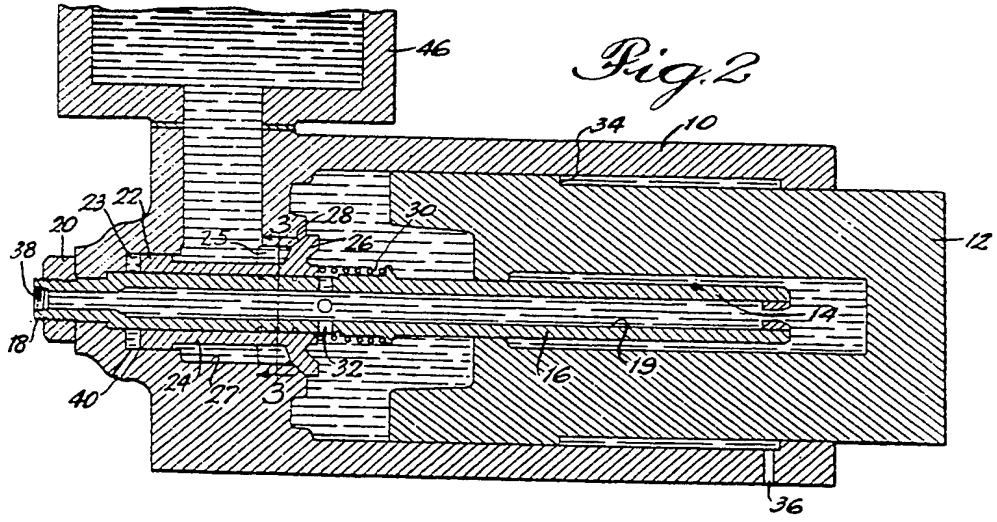
Fig. 2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843,328 COMPLETE SPECIFICATION
2 SHEETS

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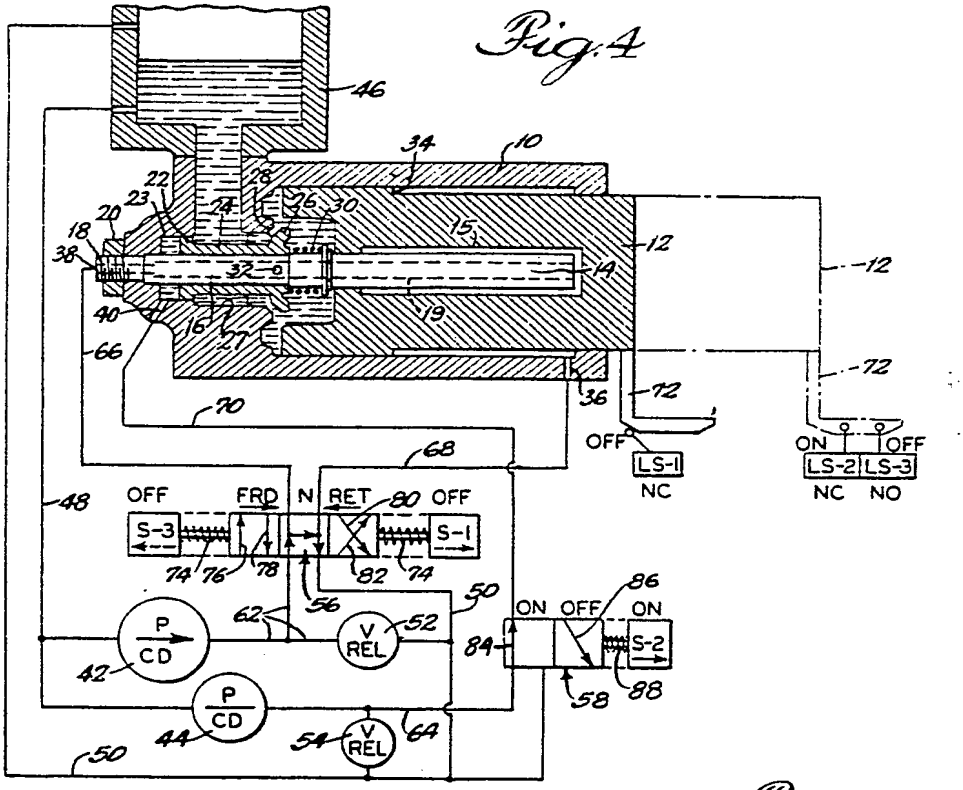
SHEETS 1 & 2

Fig. 4



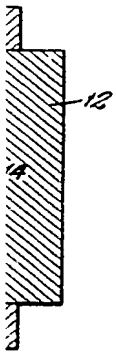
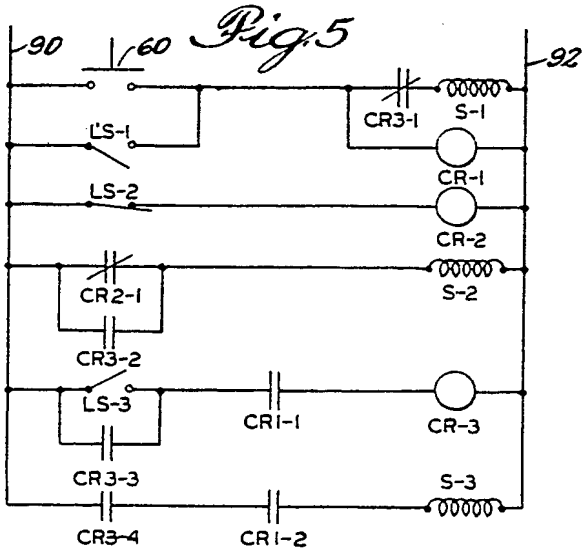


Fig. 5



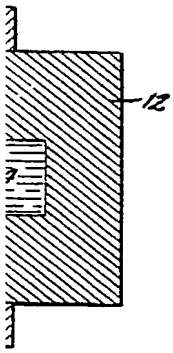
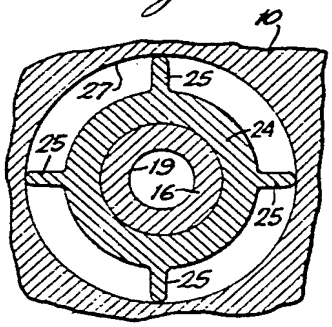


Fig. 3



843,328 COMPLETE SPECIFICATION
2 SHEETS

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SHEETS 1 & 2

Fig.1

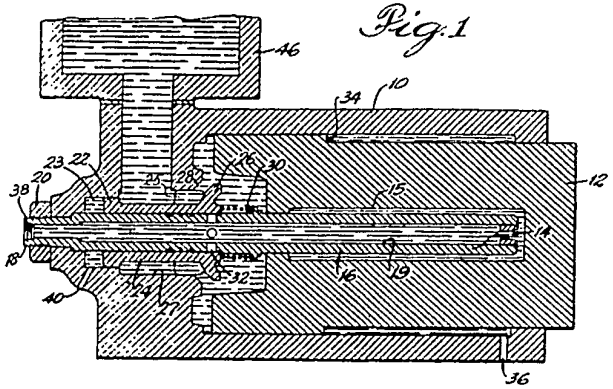

Fig.2

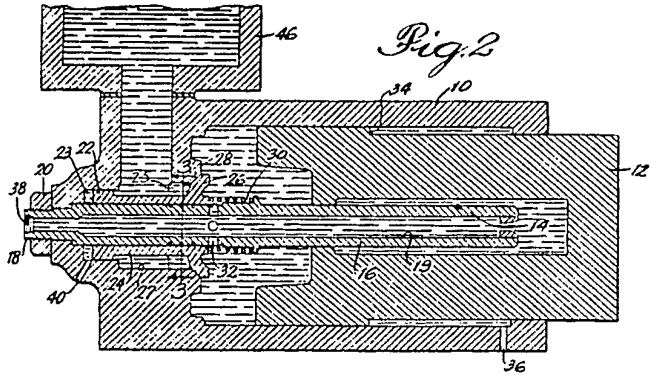

Fig.4

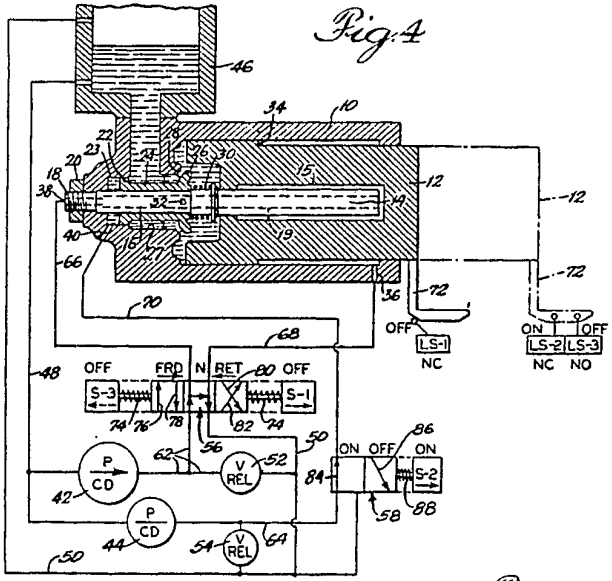

Fig.5

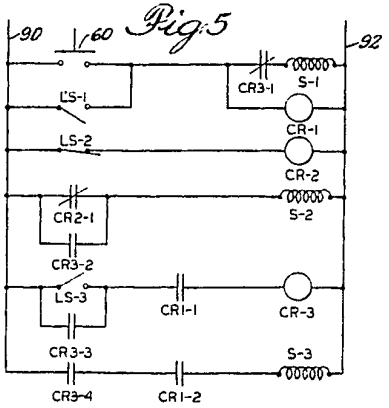

Fig.3